Afyon Mermerlerinin Jeolojik, Teknolojik ve Ayrışma Özelikleri ile Mermerlerin Sınıflandırılması

The Geological, Technological and Weathering Properties of Afyon Marbles and Their Classification

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ÖZET

Bu yazıda, Afyon mermerlerinin jeolojik ve teknolojik özelikleri incelenmiş, fiziksel ve mekanik özeliklere ayrışma derecesinin etkisi araştırılmıştır. Yapılan araştırmada, mermer ocaklarından getirilen sağlam mermer numuneleri laboratuvarda ayrıştırılmıştır. Deneyler sırasında, ayrışmış ve ayrışmamış mermerlerin ağırlıkça su emme miktarı % cinsinden saptanmış (W_n, W_o) ve bunlarla ayrışma derecesi (D_w) aşağıdaki şekilde tanımlanmıştır.

$$D_W = \frac{W_n - W_o}{W_o}$$

Deneyler sonucunda ayrışma derecesinin artması ile su emme, prozite ve birim hacmin yükseldiği ; basınç direnci ve birim hacim ağırlığının azaldığı görülmüştür.

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SUMMARY

In this article, the geological and technological properties of Afyon marbles were investigated ; and the effect of weathering on the physical and mechanical properties of marbles was also researched. Prior to the experiments fresh marble specimens were subjected to laboratory weathering. During the tests, the water absorbability by weight of weathered and intact samples, were determined as a percentage (W_n, W_o) and these were related to the degree of weathering (D_w).

$$D_w = \frac{W_n - W_o}{W_o}$$

It was observed that with increasing degree of weathering water absorbtion, porosity and sample volume increased but the compressive strength and unit weight decreased.

1 — Indtroduction

The geology of the afyon - İscehisar region with the geological and technological properties of the marbles in this area were investigated. Research was also carried out as to effect of the degree of weathering on the physical and mechanical properties of the marbles. So, Marbles were classified according to their the degree of weathering as well as their crystal dimensions, colours and places of use.

In order to investigate the relation of the physical and mechanical properties of the marbles to the degree of weathering, a new experimental method «Accelerated Weathering Test» was developed and intact marble samples were weathered accordingly. Also, the degree of weathering was proposed to be used as a criteria for classification, and it was applied to the Afyon marbles.

2 — The Geology of Afyon - Iscehiar Region

The research site is 25 kilometer north - east of Afyon and 500 kilometer from Istanbul (Turkey). This district covers an area of 150 km^2 (Fig. 1).

Metamorphic schists and marbles. conglomerates and limestone, volcanic tuffs, aglomerates and basalt lava exist in the studied region. The

schists, formed by the regional metamorphism, have the characteristics of the Chlorite Sub Facies of the Green Schist Facies as micacous schist, fillite, chlorite and sericite schist and quartzite [6]. The colour of the schists is green and sometimes brown, and they have thin sheets and white quartz lenses. Also, in these schists, quartzite layers were found. The direction of schistozity varies between N 40 - 45° W. Metamorphic schists are Paleozoik and Mesozoic age [3,8] and the thickness of them is more than 1650 meter [6].

There are a lot of faults in the investigated region and most of them extend in the same direction as schistozity. One of the important properties of these faults is the fracture zone and breccia marbles contained in them.

3 — Technological Properties of Afyon Marbles

Afyon marbles appear on the metamorphic schists with concordance and have 50 - 260 meter thickness. Physical and mechanical properties of the marbles were determined in the laboratory and their mineralogical and petrographical characteristies were investigated.

3.1 — Mineralogical Properties of the Marbles

Afyon marbles contain some secondary minerals, such as chlorite, sericite, quartz, magnetite and iron oxids near the calcite crystals. The crystal of calcite with interlocking and mosaic texture have rhombohedral cleavage and several twins (Fig. 2). The calcium carbonate content of the marbles was found between 83.83 % and 98.72 %. Crystal dimensions change from 0.2 to 0.8 milimeter, and largely 0.3 - 0.5 milimeter on the average. The number of the crystal in one square centimeter area of the marbles is between 1000 and 1700.

It has been seen from in situ investigations that marbles have two lenses with dimensions between 500 - 1300 meters and 1000 - 4500 meters. Most of the marbles are coloured, veined and with breccia structure. Main colours of the marbles were named in the following manner : white (Afyon cream), dirty yellow (Afyon yellow), bright yellow (Afyon suger), clear grey (grey marble), cherry coloured (Afyon rose), grey - blue (tiger hide), and mixture of all these colours (pidgeon breast).

3.2 — The Physical and Mechanical Properties of the marbles

The physical and mechanical properties of the Afyon marbles were determined in the laboratory and their average results were given in the following table (Tab. 1).

Table : 1 — The physical and Mechanical properties of Afyon Marbles.

Property / Marble's kind	Y	% W_v	% W_0	g	R_1	R_2	R_1/R_2	R_d	Ag
Afyon cream	2.72	0.104	0.054	2.72	840	760	0.90	680	8.4
Afyon suger	2.72	0.106	0.045	2.74	800	610	0.76	650	7.1
Grey marble	2.73	0.181	0.072	2.73	690	560	0.81	660	7.3
Tiger hide	2.73	0.159	0.065	2.74	610	540	0.88	650	11.4
Afyon rose	2.74	0.156	0.074	2.74	830	840	1.01	630	8.5
Pidgeon bosom	2.74	0.139	0.081	—	580	600	1.03	540	7.9

Y : Unit weight (gr/cm³)
W_v : Absorbtion by volume
W_0 : Absorbtion by weight
g : Specific gravity (gr/cm³)
Ag : Abrasion quantity (mm) (per 1000 m)

R_1 : Compression strength normal layer (kg/cm²)
R_2 : Compression strength parallel layer (kg/cm²)
R_d : Compression strength after frozen (kg/cm²)

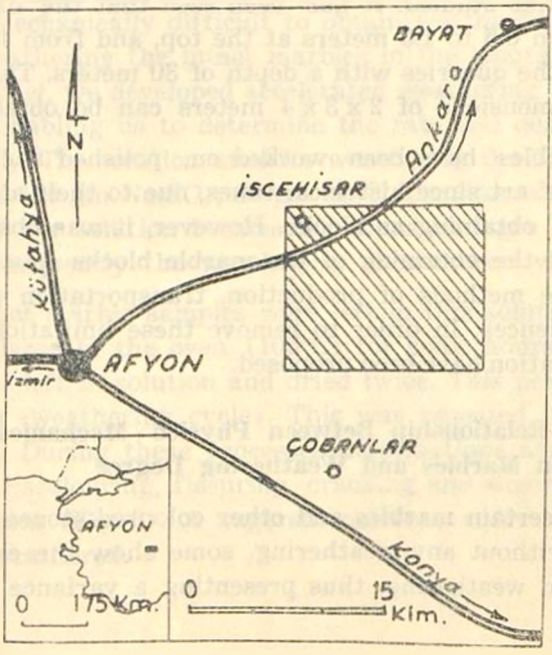

Fig. 1 : The location map of studied region.

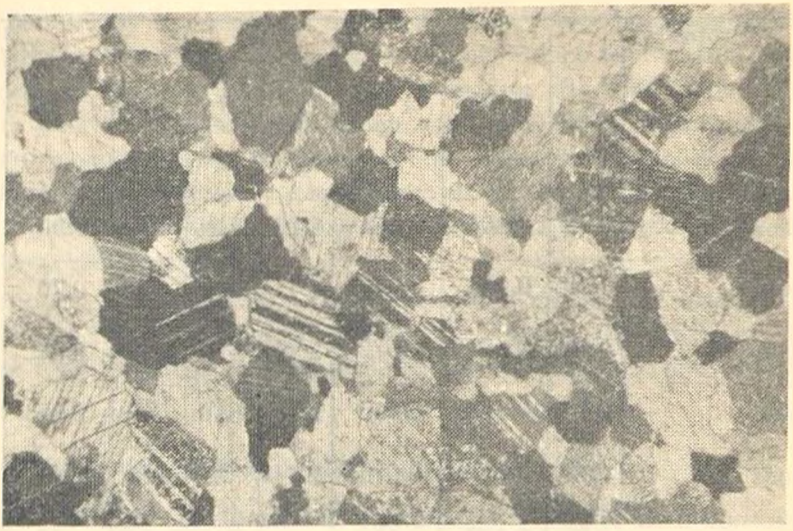

Fig. 2 : A view from the section of Afyon suger marble. X 25.

3.3 — The Working Possibilities of the Marbles Quarries

It was seen from field studies that the deposit of these marbles is more than 500 million cubic meters. The effect of joints on the removal of the blocks was studied. It has been seen that the distance between joints vary from 0.5 to 1.5 meters at the top, and from 4 to 5 meters at the bottom of the quarries with a depth of 30 meters. Therefore, the big blocks with dimensions of 2 x 3 x 4 meters can be obtained.

Afyon marbles have been worked on, polished and used in many constructions of art since historical times, due to their attractive colours and easiness of obtaining as blocks. However, it was observed from our field work that the obtaining of the marble blocks was limited because of the available methods of production, transportation difficulties, and loading inefficiences. In order to remove these limitations, the methods of modern operation have been proposed.

4 — The Relationship Between Physico - Mechanical Properties of Afyon Marbles and Weathering Degree

Although certain marbles and other coloured stones can remain for long periods without any weathering, some show the characteristics of easy decay and weathering, thus presenting a variance in colour, from

pattern and appearance. Due to these properties, the durability of rocks against weathering effects becomes an important feature, especially in the cases of external covering and ornamental marbles.

Among the many words used for the same phenomena, «weathering, alteration and disintegration» are the most commonly used. «Decay» is generally used for building stones.

According to one concept, weathering is a process of soil formation, where as another definition it includes all the change inside rocks. Our understanding and definition of weathering is the deformations and changes in the physico - mechanical properties of rocks. For this process we have adopted and used the word «Weathering» throughout.

Weathering is a phenomenan occuring due to complex physical and chemical effects, resulted from atmospheric and geologic processes. The weathering of building stones is caused, especially by the gases in the atmosphere and rain water. In accordance with the development of industry, the sulphate ions, smoke and dust composition in the atmosphere is increasing, thus effecting the rocks in various ways. These effects will not be discussed here [1, 2, 4, 12].

Up to - date publications on weathering have not included the results of any laboratory tests [7, 9]. In this research, the marble samples subjected to experiments were obtained from natural quarry deposits. Since it is mechanically difficult to obtain weathered samples with precision, to weathering the intact marbles in the laboratory was prefered. Due to this fact, we developed accelerated weathering test method in the laboratory, enabling us to determine the rate and degree of weathering quantitatively. The solution used for weathering the intact marble samples contained 100 gm Na_2SO_4, 37 gm $MgCl_2$ per liter with a pH of 5. Thus the effect of our solution became 10^4 times stronger than the rain water, and consequently the weathering phenomenon was accelerated.

The intact marble samples were left in this solution for a time and then were placed in the oven (105°C) for some hours. In 24 hours, the samples were left in solution and dried twice. This period of 24 hours is defined as a «weathering cycle». This was repeated for 25 - 30 days on each marble. During these processes deformations and increases in absorbability, discolouring, fissuring, cracking and sugering were observed on 123 samples (Fig. 3). A sugered marble sample was accepted to be completely weathered.

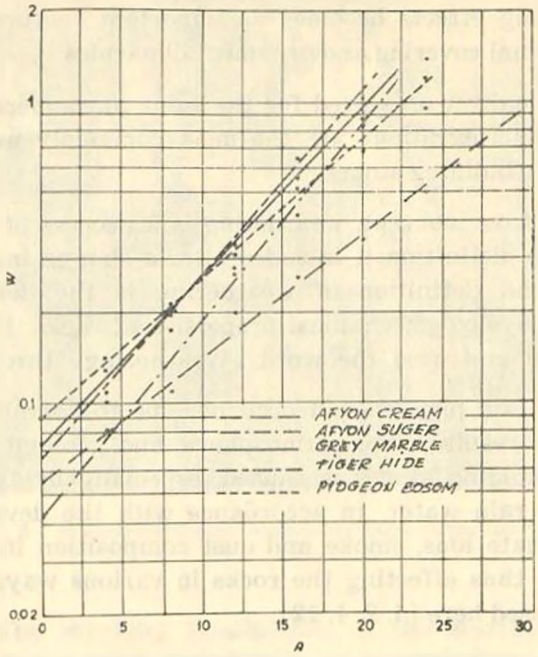

Fig. 3 : The rerationship between the cycle of weathering (A) with absorption by weight (%).

During these test, the water absorbability by weight of weathered and intact samples, were determined as a percentage (W_n, W_o) and these related to the degree of weathering (D_w).

$$D_w = \frac{W_n - W_o}{W_o}$$

The Afyon (Turkey) marbles have been classified in accordance with this formula (Tab. 3).

On marble samples, with a determined degree of weathering, the changes of the physical and mechanical properties were also investigated. As a rasult, it was observed that, with increasing degree of weathering ; water absorbtion, porosity, sample volume and abrasion quantity increased, but compressive strength, unit volume and module of elasticity decreased (Fig. 4, 5, 6, 7). Also, with increasing D_w, boundaries between crystal, twin and cleavage planes showed deformations a tendency to vanish.

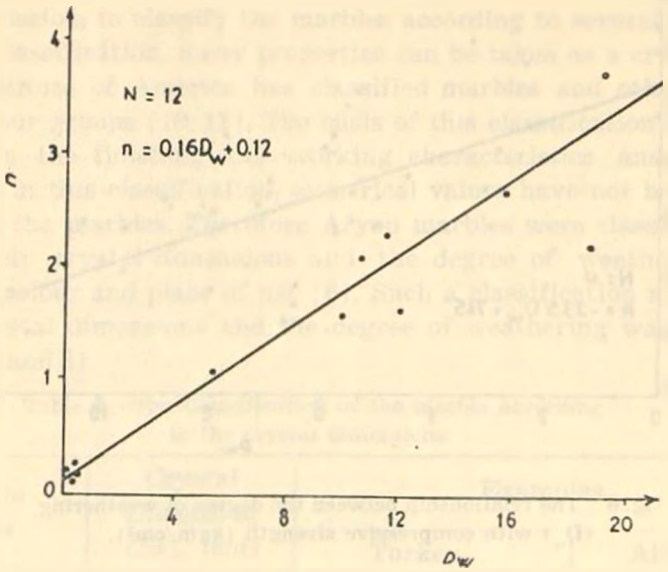

Fig. 4 : The relationship between the degree of weathering (D_w) with porosity (%).

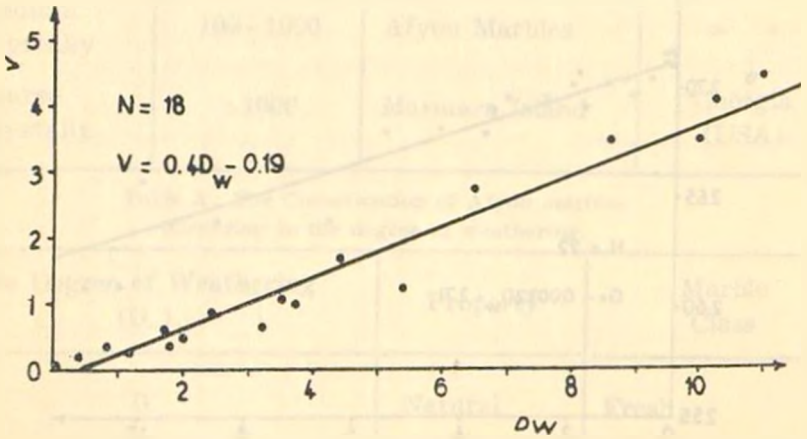

Fig. 5 : The relationship between the degree of weathering (D_w) with sample volume (%).

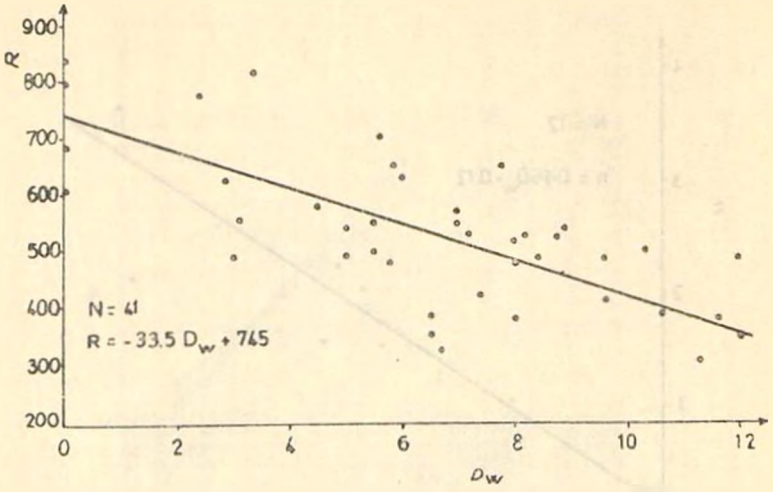

Fig. 6 : The relationship between the degree of weathering (D_w) with compressive strength (kgm/cm²).

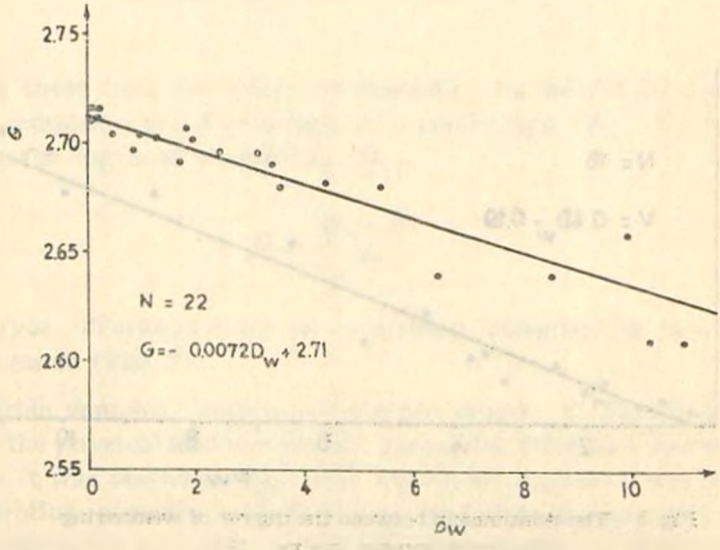

Fig. 7 : The relationship between the degree of weathering (D_w) with unit weight (gm/cm³).

5 — The Classification of Afyon Marbles

It is possible to classify the marbles according to several properties. In such a classification, many properties can be taken as a criterion. The Marble Institute of America has classified marbles and other coloured stones in four groups [10, 11]. The basis of this classification is the classification is the finishing and working characteristics and geological faults. But in this classification, numerical values have not been used to distinquish the marbles. Therefore Afyon marbles were classified according to their crystal dimensions and the degree of weathering apart from their colour and place of use [6]. Such a classification made according to crystal dimensions and the degree of weathering was given below (Tab. 2 and 3).

Table 2 : The Classification of the marble according to the crystal dimensions.

Marble Class	Crystal Dimension (10^{-3} mm)	Examples	
		Turkey	Abroad
Very fine Crystally	<50	—	Yule (USA)
Fine Crystally	50 - 100	Marmara Island Dolomite	Carrara (İtaly)
Medium Crystally	100 - 1000	Afyon Marbles	» »
Coarse Crystally	>1000	Marmara Island	Georgia (USA)

Table 3 : The Classification of Afyon marbles according to the degree of weathering.

The Degree of Weathering (D_w)	Property	Marble Class
0	Natural	Fresh
0 — 4	Discolouring	Few weathered
4 — 8	Fissuring	Medium weathered
8 — 12	Cracking	Weathered
>12	Sugering	More weathered

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